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Applications of Conductive Polymers as Sensitizers

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Abstract: Polymers are large molecules consisting of small units linked together called units monomer. Polymers are sometimes crystalline in structure, and sometimes amorphous, or a mixture of the two. The vast majority of polymers lack good electrical conductivity, so their uses were limited depending on their mechanical properties and chemical properties. As for their electrical uses, they were limited to electrical insulators because these materials have good electrical insulation properties. In 1977, one of these insulating organic polymers (Poly) was discovered. Acetylene (PA), which can be transformed into a conductive polymer by treating it with suitable impurities by oxidation-reduction process, followed by the emergence of different types of cyclic and aromatic polymers that exhibit the same.

This behavior of these polymers formed a new type or group called conductive polymers. (Conducting polymers) This type of polymers quickly gained great interest

Broadly, and it can be said that the main motive behind this interest is theuse of these materials in the field of industrial applications, especially electronic ones, because of the good properties of these materials in termsof cheap cost, ease of manufacture, the need for low deposition temperatures and the large area in addition to the characteristics of thesematerials from Also, (electro activity) is effective because obtaining integrated electronic circuits with sub-micro dimensions using these materials is much easier than using inorganic semiconductor technology,as the use of these polymers in the field of electronic applications opened a new branch known as molecular electronics.

Classification of polymers according to their structural composition:Linear polymers:

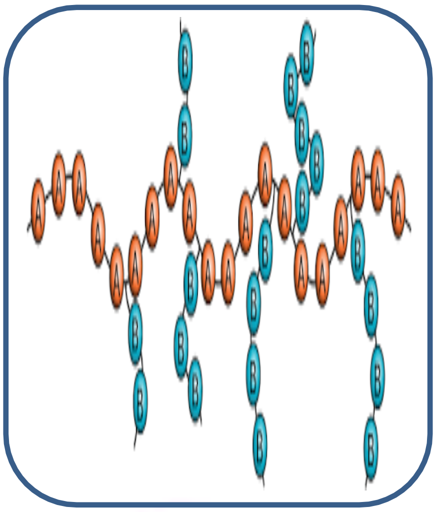
In these polymers, the structural unit is connected to each other in acontinuous linear fashion

Branched Polymers:

Branched polymers are formed either due to the use of monomers of multiple side groups, the polymer molecule is branched and the branchingdiffers in terms of the length of the side branch signed on the polymer chain, these branches may be arranged in a cruciform shape on the mainchain or in a comb or ladder shape

Crosslinked polymers:

The polymeric chain in this classification of polymers is entangled with each other and bound together by more than one site.



B

A

Electroactive polymers or electrolytic polymers

(Electro active polymers)

They are polymers that show a change in size or shape when stimulated by an electric field

The most common applications for this type of material are:

. Mechanical actuators. and sensors

One of the distinguishing properties of electrically active polymers is that no matter how much crushing force they are subjected to, they will maintain great forces and last for long periods.

Most older mechanical actuators are made of piezoelectric piezoelectric ceramic materials. These materials are able to withstand large forces, andthese forces will only deform a small percentage of them. In the late 1990s, it was proven that some electrically active polymers can withstand stresses up to (380%), which is much greater than the bearing capacity ofany mechanical actuator made of ceramics. One of the most common applications of electrically active polymers is in the field of robotics in the field of artificial muscle development, and therefore electrically active polymers are often referred to as artificial muscle.

Types of electroactive polymers

Electrically active polymers are generally divided into two main categories: dielectric and ionic.

1-41 Electroactive Dielectric Polymers

Electrically active insulating polymers are materials that are activated by the electrostatic forces between two electrodes applied to the polymer. Dielectric elastomers are capable of producing extremely high pressure, and are essentially a capacitor that changes its capacitance when a resultant voltage is applied by allowing the polymer to compress its thickness and expand its area due to the electric field. This type of electrically active insulating polymer usually requires a large operating voltage (hundreds to thousands of volts) to produce high electric fields, but its electrical energy

consumption is very low, and it does not require any energy to keep the actuators in a particular state. Examples are

Ferroelectric polymers

Electrodoped polymers or electrolytic polymers

- liquid crystalline polymers
- Insulating plastics

1-4-2

Electroactive ionic polymers

Electrically active ionic polymers are materials that are activated by sequestering ions within the polymer. Their operating voltage is very low, but ionic flux requires higherelectrical energy to operate, and energy is needed to maintain the actuators in a particular state Examples of electroactive ionic polymers are: conductive polymers, electrorheological fluids, metallic ionic polymers, and catalytic responsive gels. and a buckyball gel actuator, a polymer-supported polyelectrolyte layer consisting of an ionic liquid sandwiched between two polar layers consisting of a gel of ionic liquid containing single-walled carbon nanotubes. The name comes from the gel's similarity to paper, which can be made by filtering carbon nanotubes, or buckypaper.

Comparison of electrically active insulating and ionic polymers

Insulating polymers are able to maintain their induced displacement while being activated under constant voltage, and this gives them an advantage for use in automated applications. These types of materials are also characterized by density

High mechanical energy and can be operated in the air without significant reduction in performance. However, insulating polymers require very high activation fields (pin/V < 10) that are close to the breakdown level.

On the other hand, activation of ionic polymers requires only (1-2) volts. However, it does need to remain moist, although some polymers have been developed to containself-encapsulating dopants that allow it to be used in dry environments. Mechanical conductivities in ionic polymers are few, and thus are ideal for biomimetics.

1-6 The mechanism of conduction in polymers:

The process of determining the mechanism of electrical conduction is a difficult and complex process due to the transfer of charge carriers between the metal electrode and the polymer membrane on the one hand, and through the polymeric material on the other hand. The conductivity changes with temperature and current density with thickness of the polymer film and the root square root of the field with current

Among the mechanisms known to determine the conductivity of polymers:

Jump delivery mechanism:

Scientists Miller and Abrahams discovered in 1960 the possibility ofelectrical conduction in organic semiconductors as a result of the movement of thermally activated charge carriers from one location to another. Gain sufficient thermal energy to enable it to cross the voltage barrier to an energy level higher than the Fermi level (39)

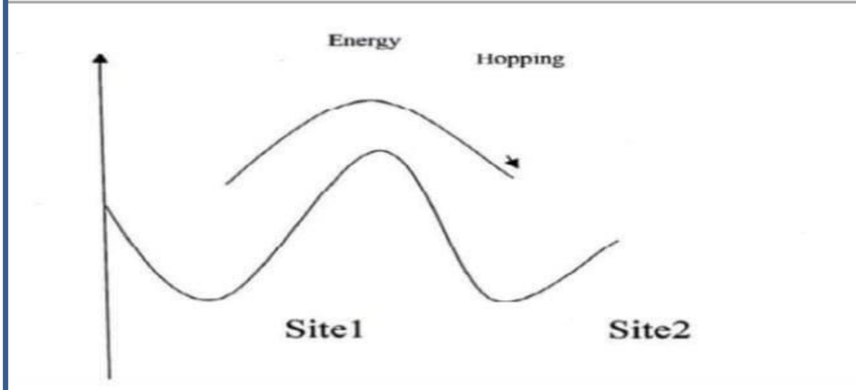
The movement of charge carriers from one location to another neighboring location is called jump conduction, but if the charge carriers move to a non-adjacent site, it is called variable range hopping (VRH) and this typeoften occurs at citizen temperatures (46).

The electrical conductivity relationship with temperature can be written as:

whereas

= electrical conductivityA = proactive factor

m = constant that depends on the nature of the substanceT = absolute temperature



شكل (9- 1) عملية انتقال الكترون بين موقعين بينهما حاجز جهد (40)

Excavation Mechanism:

It is one of the mechanisms for the transfer of potential charge carriers in materials with a molecular crystal pattern as well as in polymers, and it is based on the tunneling effect in quantum mechanics. This mechanism imposes that the electrons penetrate the voltage barriers. What distinguishes this mechanism is the calculation of the probability of electrons moving through the voltage barrier using quantum mechanics, and that the difference between one state from another results from the difference in the wave function and the shape of the voltage barrier. The tunneling mechanism can be clarified (metal-polymer-metal)

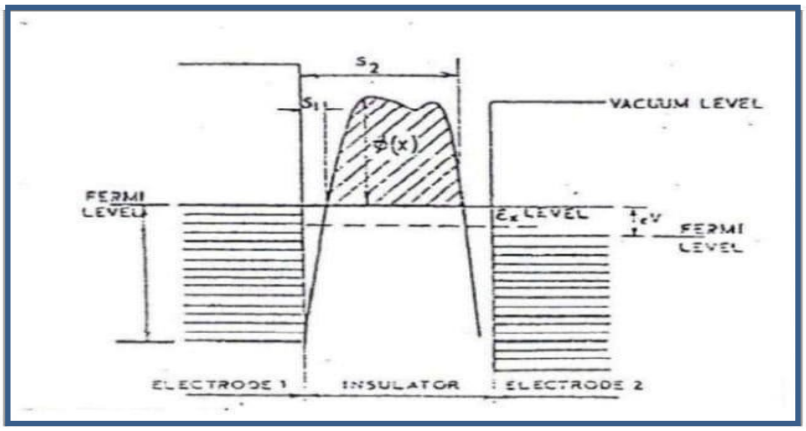


Figure (2) The tunneling mechanism (metal-polymer-metal)

Ion conduction mechanism:

The ionic conductivity depends directly on the presence of positive and negative free ions. The source of free ions in natural insulating materials is the chemical composition or ionic salts added to the insulating material such as sodium and lithium salts, if these salts are a source of ions that have the

ability to move at laboratory temperature. An example of ionic conduction polymers that have the ability to conduct is polyvinyl chloride.

Applications

Electroactive polymer materials can be easily manufactured into various shapes due to the ease of processing many polymeric materials, making them a very versatile material. One potential application of polymers is their potential for incorporation into microelectromechanical systems to produce intelligent actuators.

Artificial muscles

Electrically active polymers have been used and are still used in artificial muscles as the most advanced practical research direction into the future,attracting the attention of scientists because of their ability to match the operation of biological muscles with high strength against fracture, high operating stress and inherent vibration damping.

. Touch screens for the blind

. Microfluidics 1-7-2plastic neurons

Today, neuropsychiatric diseases are treated mainly with the help of drugs, but it can be very difficult to find their doses and deliver the drug to specific cells while taking into account its side effects on a variety of processes in the body. A large team of Swedish scientists from several institutes proposed to solve these problems by using the same electrically conducting polymers, or rather by using another organic bioelectronic device. An organic electronic ion pump capable of pumping ions from one medium to another.

In their work, the researchers studied laboratory mice in which they firstcaused neuropathic pain (the septa is not an external stinger, but the impaired functioning of the neurons themselves), and then treated it withthe help of a droplet injection of a neurotransmitter. GABA (gamma- aminobutyric acid) which reduces the irritation of the central nervous system. A mini organoid pump (about 12 cm long) was injected.

It was 6 mm in diameter in the rat spinal cord, and its reservoir was filledwith GABA (Fig. 1). With the application of an external electric potential, GABA molecules began to exit through four ion-conducting polymerchannels into the intercellular space.

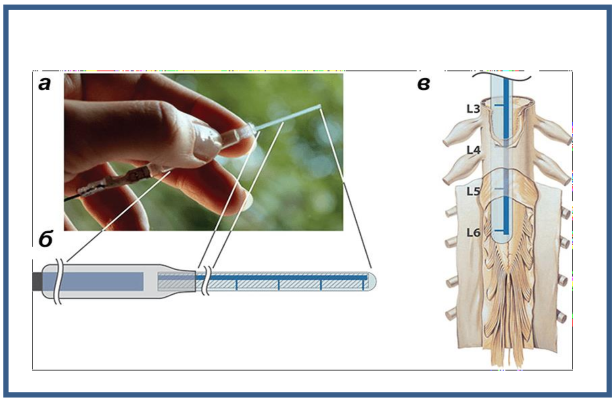


Figure (1)

Figure 1. An implantable organic electrochemical pump. a. Photo of the device, b - a schematic representation of the device, on the left - the electrical connection, in the center - the tank with GABA, on the right - theoutflow channels. The total length of the device is 120 mm, the tank diameter is 6 mm.

c. Four electrochemical organ sockets are located at those points where the branches of the sciatic nerve enter the spinal cord.

As a result, the pain disappeared in the rats (verified using a tactile test: elastic threads of different stiffness were brought to the rat's feet and monitored from the pressure that the animal will pull its paw), and no side effects are observed. With all other methods of treating nerve pain with GABA, the drug is injected intothe spinal cord in a large dose

pain it

Which is distributed throughout the nervous system and in addition to relieving leads to impaired walking, lethargy and other side effects.

Parallel to this work, the same group of researchers made the first polymer-based artificial neuron. In it, an ion pump is integrated with the sensitive biosensors glutamic acid (the most common neurotransmitter) and acetylcholine.

A neurotransmitter that transmits a signal from nerve cells to muscle tissue). For example, in one experiment, a "plastic" neuron monitored the level of glutamate in a petri dish, and when a certain threshold was exceeded, a current in it excited, causing the ion pump tank to open, releasing acetylcholine into the environment

The work of artificial neurons is very similar to how a real neuron works. The nerve impulse is excited in one of them and passes through the whole cell to the point of contact with another neuron, glutamic acid is releasedthere, which, as it were, presses a button and excites the next neuron (Fig.2). So, along a chain of neurons, the impulse reaches the muscle cell, which is actually stimulated not by glutamic acid, but by acetylcholine. The plastic neurons created by the Swedes can easily repeat these actions and transmit signals to other cells. In the experiment, these were neuroblastoma cells SH-SY5Y, whose activation was monitored by characteristic increases in ion concentration upon acetylcholine receptor binding.

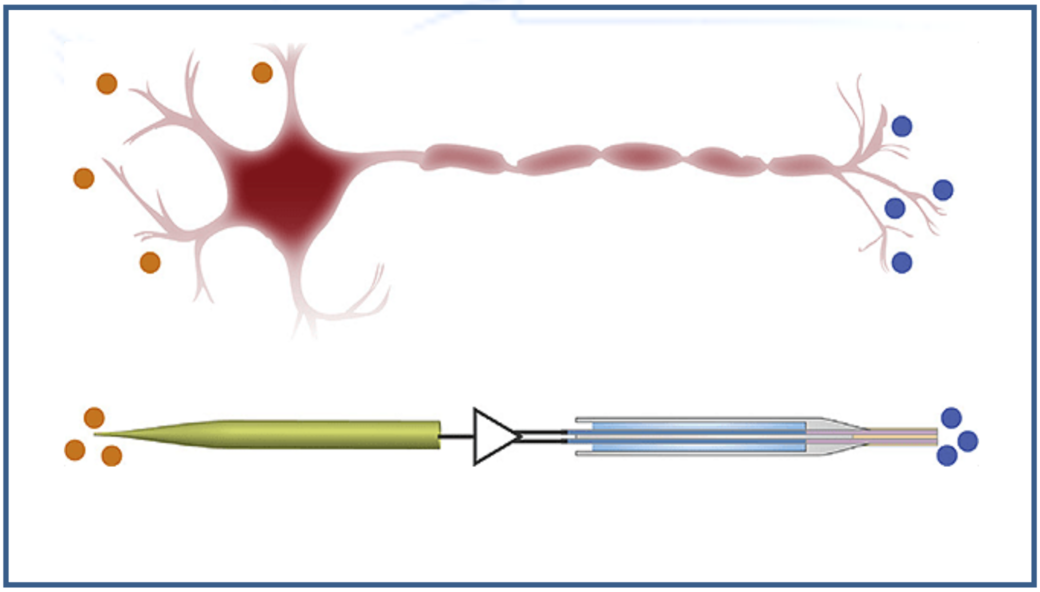


Figure 2

Scheme of converting a chemical signal to an electrical signal and back to an artificial polymer neuron identical to that of a live neuron. Biosensor (represented in green) reacts with an increased concentration of one neurotransmitter (orange dots), which generates an electron flow that excites an organic electrochemical pump (represented in blue), which secretes another neurotransmitter (blue dots)

From electronic roses to green energy:

In the first experiment, a cut rose was placed in water using a dissolved electrically conductive polymer, which climbed the handle and formed a conductive channel in the rose. Then the scientists brought electrical contacts to the ends of the channel and inserted a control electrode into the handle - a gold wire covered with a conductive polymer. So a kind oforganic transistor was assembled inside the rosette. At the same time, several control electrodes can be connected to one channel at once and a simple logic circuit can be created, through which current flows only whena certain control voltage is applied to both gold wires

In the second experiment, an aqueous solution of another conductive

polymer, which can change color when an external voltage is applied, waspumped into rosette leaves using a syringe. The electrodes were broughtinto the paper, the current was turned on and - voila: the veins of the leaftook on a bluish-green color. It was the polymer injected into it that turnedfrom colorless to blue. At the same time, when the stress was removed, the leaf returned to a healthy green color.

So scientists have shown that with the help of simple technologies inside plants, simple electronic circuits can be created in the long term, this willallow them to control their functions and, for example, achieve higher yields without genetic modifications, or even create small power plants onthe energy of photosynthesis. Of course, while this sounds very expensive,one day organic bioelectronics technologies will make it possible to precisely control every plant, not the entire population at once.

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